CLAIMS

What is claimed is:

1. A method for determining a pointing error of an object attached to a shaft, comprising:

providing a set of distance measuring probes at each end of the shaft;

using the probes, measuring a position of each end of the shaft for producing shaft-end position data;

determining a geometric error vector for each end of the shaft from the shaft-end position data; and,

using the geometric error vector, determining the pointing error of the object.

2. The method as in claim 1, wherein determining the geometric error vector comprises:

referring to a source of characterization data comprising repeatable error data to obtain a repeatable error component corresponding to a location of the shaft; and,

subtracting the repeatable error component from the position data to produce a non-repeatable error component.

- 3. The method as in claim 2, further comprising calculating angular error, Δ_{az} , Δ_{el} , from the non-repeatable error component.
- 4. The method as in claim 3, further comprising calculating the pointing error, MOA_ERROR , from the angular error, Δ_{az} , Δ_{el} .
- 5. The method as in claim 1, wherein providing the set of distance measuring probes comprises providing a first probe of the set to be disposed at an angle of about 90 degrees to a second probe of the set.
- 6. The method as in claim 1, wherein the geometric error vector indicates an angular position and a magnitude of an error producing feature of the shaft.

7. An apparatus for determining a pointing error of an object attached to a shaft, comprising:

a set of distance measuring probes disposed at each end of the shaft adapted for monitoring a position of the shaft and producing shaft-end position data, the set of distance measuring probes being coupled to a processor for receiving the shaft-end position data and determining a geometric error vector for each end of the shaft and using the geometric error vector, determining the pointing error of the object.

- 8. The apparatus as in claim 7, wherein the shaft is disposed aboard a spacecraft, and where the object comprises a mirror.
- 9. The apparatus as in claim 7, wherein the object comprises at least one of a telescope, a mirror, a laser, a laser transceiver, and an angular measurement device.
- 10. The apparatus as in claim 7, wherein the set of distance measuring probes comprises a set of eddy current proximity sensors.
- 11. The apparatus as in claim 10, wherein the set of eddy current proximity sensors comprises dual channel eddy current proximity sensors.
- 12. The apparatus as in claim 7, comprising a first bearing assembly coupled to respective ends of the shaft.
- 13. The apparatus as in claim 12, comprising a gimbal coupled to the first bearing assembly.
- 14. The apparatus as in claim 13, comprising a second bearing assembly coupled to the gimbal.
- 15. The apparatus as in claim 14, wherein the set of distance measuring probes is adapted for monitoring at least one of the gimbal and a position of at least one of an inner ring and an outer ring of a respective bearing assembly.

- 16. The apparatus as in claim 7, comprising at least one flange for monitoring by the set of distance measuring probes.
- 17. The apparatus as in claim 16, wherein the at least one flange comprises one of passivated steel, aluminum and titanium.
- 18. The apparatus as in claim 7, wherein the apparatus is adapted for shielding the set of distance measuring probes from thermal effects.
- 19. A method for characterizing a repeatable position error in a pointing device attached to a shaft supported by bearings, comprising:

providing a set of distance measuring probes at each end of the shaft; setting the shaft to a predetermined location;

measuring a position of each end of the shaft at the predetermined location for producing position data;

determining a geometric error vector from the position data for each end of the shaft;

using the geometric error vector, determining a pointing error of the pointing device;

storing the pointing error for each predetermined location to establish a pointing error record;

repeating the determining of the pointing error until a new determination of pointing error for a predetermined location is within an acceptable tolerance for agreement with the pointing error record; and,

identifying the pointing error stored in the pointing error record as repeatable position error data.

- 20. The method as in claim 19, wherein the measuring is performed at a predetermined temperature.
- 21. The method as in claim 19, wherein the pointing device is disposed aboard a spacecraft.

22. A computer program product stored on a computer readable storage medium, comprising computer readable program code instructions to determine a pointing error of an object, the instructions comprising steps for:

producing measurement data for a location of the object by measuring a position of a shaft with a set of distance measuring sensors disposed at each end of the shaft to which the object is attached;

determining a geometric error vector for each end of the shaft from the position data; and,

using the geometric error vector, determining the pointing error of the object.

- 23. The computer program product as in claim 22, further comprising instructions for communicating at least one of the measurement data and the pointing error to a remote station.
- 24. A method for determining pointing error of a pointing device, the method comprising:

providing the pointing device attached to a shaft, the shaft coupled to a first bearing assembly rotating about a first axis, and coupled to a second bearing assembly rotating about a second axis, and a set of distance measuring sensors adapted to monitor the position of the pointing device;

measuring the position of the pointing device along the first axis and the second axis to produce position data, ds;

retrieving repeatable error data from a source of calibration data to produce a repeatable error component;

subtracting the repeatable error component from the position data, ds, to produce a non-repeatable error component, ads;

using the non-repeatable error component, ads, computing a first axis position error, Δ_{az} , and computing a second axis position error, Δ_{el} ; and,

computing the pointing device error, MOA ERROR, as

$$MOA_ERROR = \begin{bmatrix} \Delta_{azy}.\cos(el + \pi/4) - \Delta_{el}.\sin az \\ -\Delta_{azx}.\cos(el + \pi/4) + \Delta_{el}.\cos az \\ \sin(el + \pi/4)(-\Delta_{azy}.\cos az + \Delta_{azx}.\sin az) \end{bmatrix}; \text{ where } \Delta_{azy} \text{ denotes a}$$

y-axis component of the first axis position error, Δ_{az} ; Δ_{azx} denotes a x-axis component of the first axis position error, Δ_{az} ; el denotes an angle in the second axis, and az denotes an angle in the first axis.

25. A method for compensating for pointing error in a pointing device attached to a shaft of a spacecraft, comprising:

providing a set of distance measuring probes at each end of the shaft; measuring a position of each end of the shaft for producing position data;

determining a geometric error vector for each end of the shaft from the position data;

using the geometric error vector, determining the pointing error of the pointing device;

using the pointing error to adjust one of a position of the pointing device and a set of data produced by the pointing device.